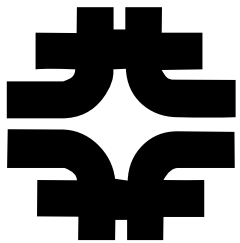
On the Luminosity Ratio at CDF and D0



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Introduction: motivation

- As suggested by V. Shiltsev, let us investigate why the Luminosity seems to be systematically higher (by about 5 to 7 %) at CDF than at D0.
- Is this real? If so, why so, and what does it tell us on the machine performance?
- More specifically, the precision measurements of the transverse and longitudinal effective beam sizes at the I.R. (spatial integration of the overlap of the bunches at CDF and D0) is highly relevant for both machine studies and, of course, physics.
- This note is only the first step, there is a lot more to come.

Status.

- Contact people at CDF (Ming Wang..) and at D0 (Gaston Gutierrez) to get data on beam width. Clearly, this problem is also on their mind, and it is a good thing.
- Think and discuss.. About total x-section, beam sizes, Luminosity, how it is measured and so forth…
- Preliminary results on the first ingredient: Products of bunch intensities at B0 and D0.

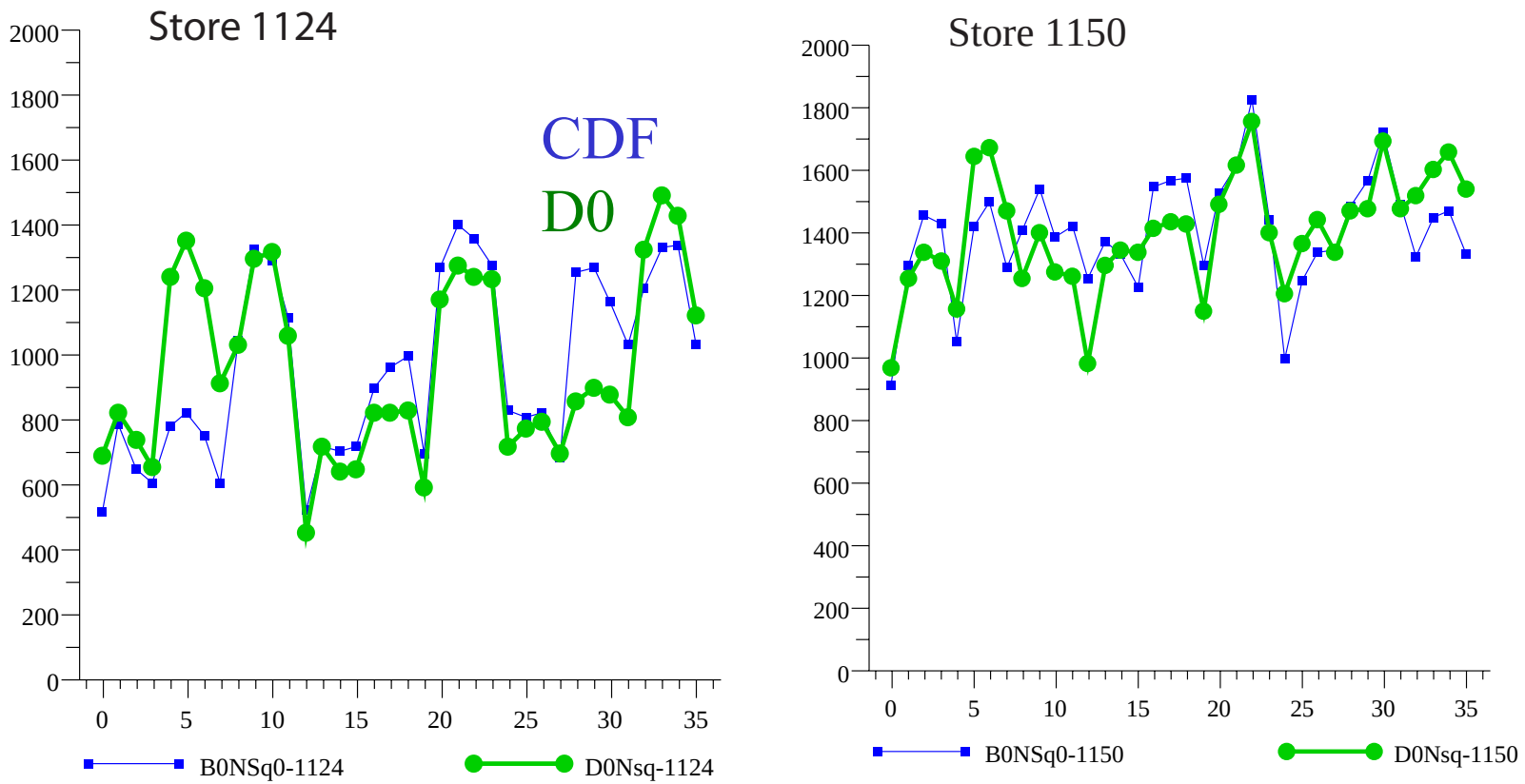
On the Luminosity and total X-section…

- Assuming the X-section is known, all relevant machine parameters are known (Np, Na, ε, β*…), we could "predict" the Luminosity at CDF and D0, allowing for a cross-check.
- Although we are not ready to do this yet (calibration of Sync Light, luminosity counters..), it is worth giving you an update, and learn along the way..
- Do we know the total p-pBar X-section? How is it measured. How well is it known?

On the total X-section…

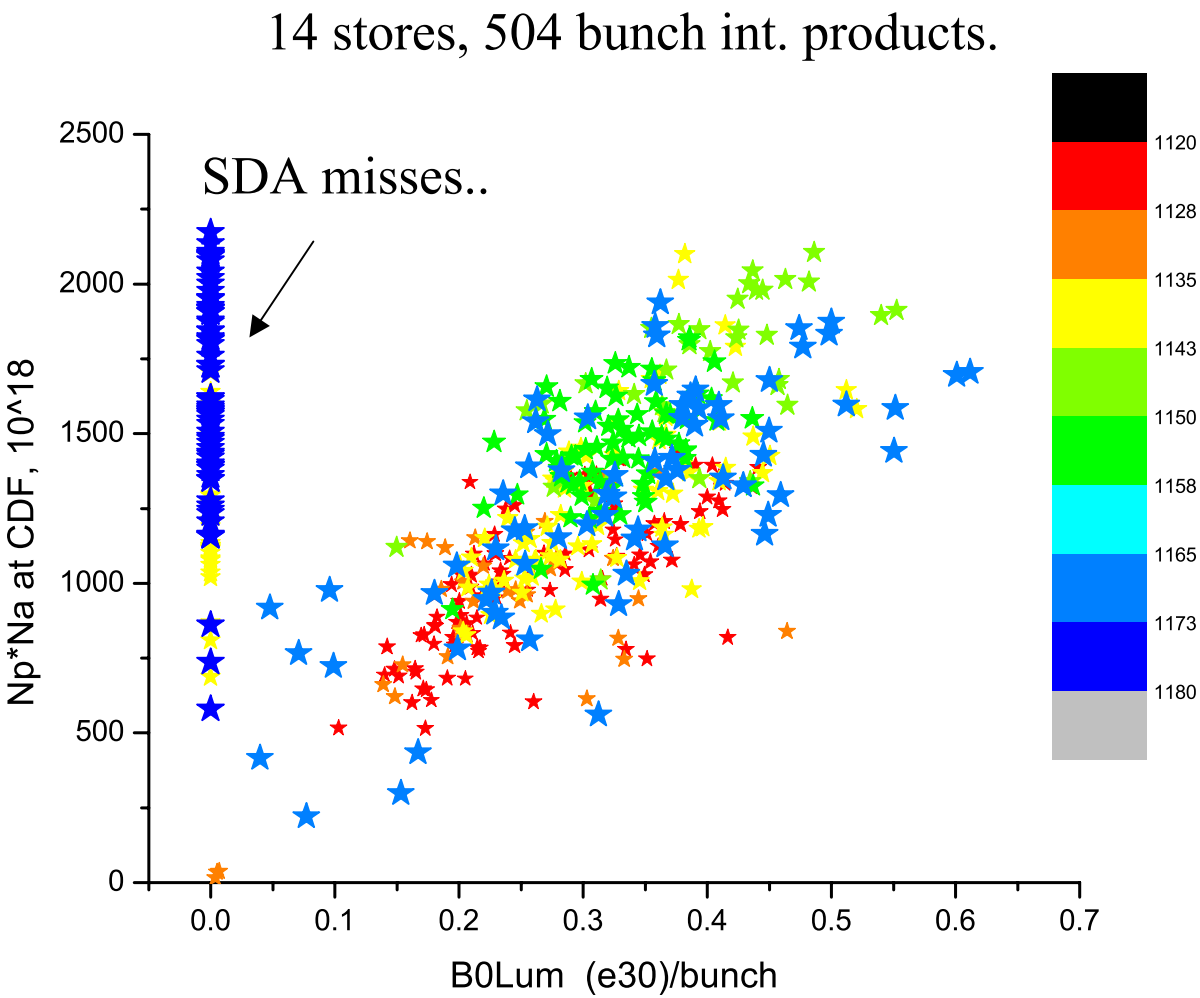
- Measurements:
  - E710: 72.8 +- 3.1 mB Phys. Rev Lett 68 (1992) 2433
  - E811: 71.71 +- 2.02 mB Phys. Lett. B445(1999) 419
  - CDF: 80.03 +- 2.24 mB Phys. Rev. D50 (1994) 5550
- Method: not done by relying on a naïve Luminosity calculation! Instead, one rely on the optical theorem, the measurement of the ratio of the real to imaginary part of the scattering amplitude and the ratio of the elastic over inelastic X-section to deduce the total x-section.
- Which x-section is assumed at CDF and D0? How do we calibrate the Luminosity counters? Other physics assumptions are probably made. (correction for multiplicity fluctuations, acceptance over the relevant rapidity range and azimuthal coverage).

On the first ingredient: Np * Na (device C:FBIPNG, C:FBIANG)



Bunch counting rule: CDF : Prot. Bunch on same pBar Bunch
D0 : Prot. Bunch on pBar bunch + 24, mod 36

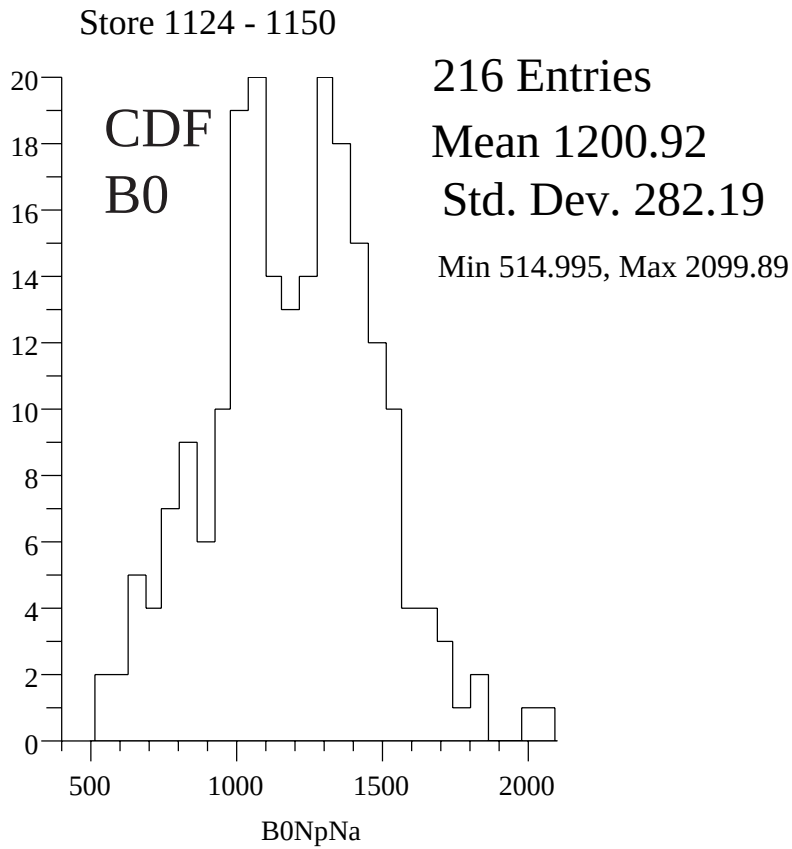
Is this product correlated with B0Lum counter?

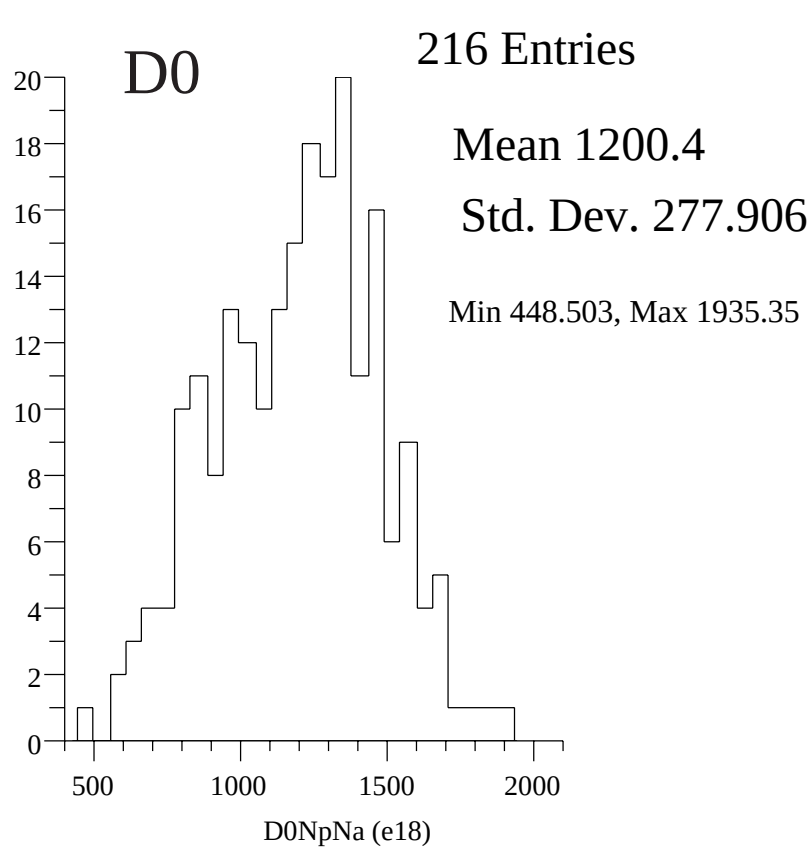


Yes,
With
Large
Fluctuations
~ 10 % !
Emittance
Fluctuations!

Histograms of of the Np*Na product, D0 and CDF

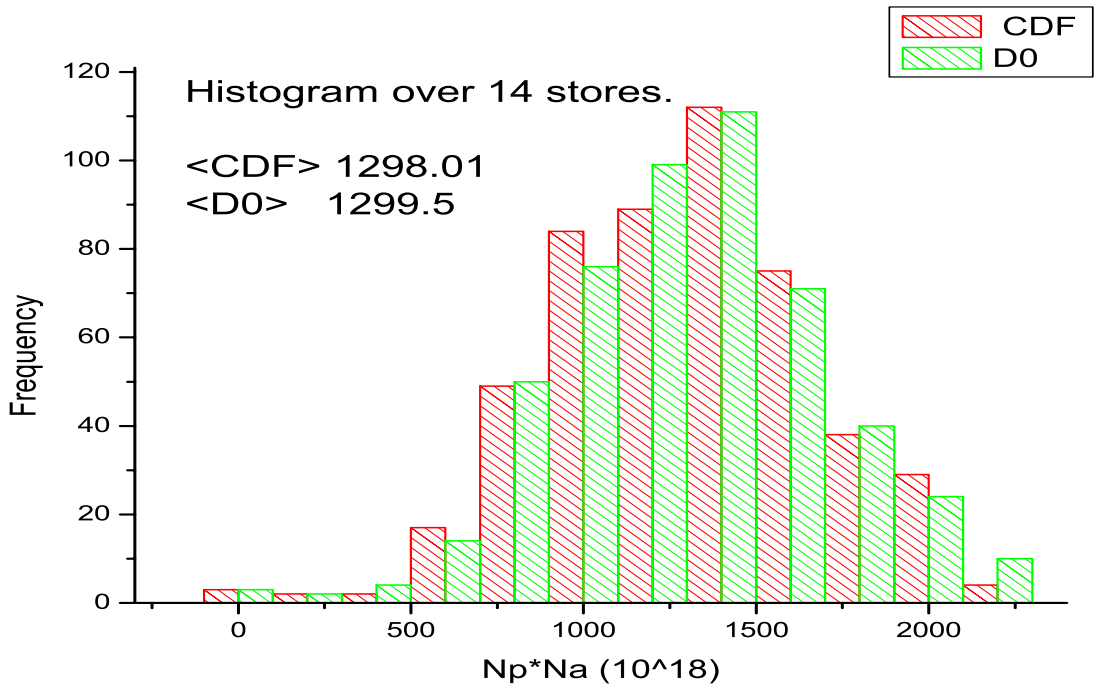
6 stores…





Histograms of of the Np*Na product, D0 and CDF

14 stores…



Why are the averages of (NaNp) D0 vs CDF so close ?

- The average of Np*Na CDF vs D0, for these 6 stores, or 14 stores, or in fact, for each individual are equal within a fraction of 1%. It is not a coincidence.. And there is a simple explanation (I think..)
- The difference (CDF - D0) in these average (or sum) suppose to be proportional to be equal to :

  nP1*(nA1-nA25) + nP2*(nA2-nA26) + … +

  nP13*(nA13-nA1) + ….. + nP25*(nA25-nA13) + ….

  Vanishes if nP1 = nP25… or nA1=nA25, ….

➔ Vanishes identically if either all Proton bunch intensities or all antiproton bunch intensities are equal.

ΔNpNA/NpNa << 7% !

- Due a "cyclic" cancellation property of this sum, the relative difference between CDF and D0 must be related to the product of relative sigmas in the Np and Na distributions, for the 36 bunches, which are typically 7% and 15% , respectively.
- Not a mathematical theorem, a guess based on some statistical studies..

More to Come….

- Start calibrating Sync Light, Flying wires, so that we can correlate Luminosity counters with emittances. (Stephen Pordes, Harry Cheung)
- Use the beam width measurements at CDF and D0, correlate those with emittance measurement.(see plot from Ming Wang)
- Attempt at computing luminosity from simple formula, and compare..
- But this will take some time!.